THE EFFECT OF SOUND DISTRACTION UPON MEMORY[1]

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I. INTRODUCTION

The writer of this article has recently published[2] a monograph reporting the results of an experiment designed to test the effect of sound disturbance upon continuous complex reaction to visually presented material. This experiment showed clearly that the extra resistance to free reaction which the distraction set up had the effect of causing the subjects to exert extra energy to overcome the disturbance, and to aid themselves by articulating the letters and numbers that were involved as intermediate steps in the reactions. As a result of the use of extra energy and the aid of articulation the subjects were enabled after a brief period of adaptation to make as good time and to do as accurate work during noise disturbance as during quiet.

Since noise causes an extra discharge of energy and the adoption of some scheme to overcome disturbance it must follow, either that noise has a dynamogenic effect, or that there is some general tendency to meet increased resistance to the customary response with an extra output of energy to overcome the increased resistance. Support for the latter conclusion was found in a weight lifting experiment, where it was found that a change in the size of the weight was accompanied by a change in the force exerted, despite the fact that the subjects were instructed to do their best all the time. Hence the conclusion was submitted that any change in the resistance offered to the maintenance of the pace adopted by the reagent causes a change in the output of energy.

Professor Woodworth has recently performed some experiments which point to a similar conclusion in the case of memorizing lists of word paired-associates. From a number of different experiments with various class groups he found that the percentage of material retained after two days increased

[1] From the psychological laboratory of Columbia University.

[2] The Overcoming of Distraction and Other Resistances. *Archives of Psychol.*, 1916, No. 35.

with the length of lists used in the presentation. After informing the class of the size of the list to be given, the pairs were read. Immediately the first word of each pair was again presented, the class if possible recording the correct associate, and each failure being followed by a prompting with the correct word. After three repetitions in this fashion lists of other lengths were presented. After an interval of two days retention was tested for all the lists. The fact that all the conditions of the experiment were the same with the exception that the lists were of different lengths shows that in some way the response varied with the length of the list.

One explanation that presented itself was that the long lists caused the subjects to exert greater energy and to find more lasting bonds than in the case of the shorter lists. As a bit of collateral evidence for this Professor Woodworth suggested that we examine the effect of noises upon retention. Unfortunately for a comparison of his results with those of the experiment to be presented, the apparatus that was used forced us to use material different from that used by him; this with the fact that our results came out differently from what was expected prevents their being used to any great extent for the purpose first intended. They do however supplement our previous work and show that, while one opposes extra effort against increased resistance to his set pace of activity, there are some mental processes that lose in the presence of distraction in spite of such increased effort.

II. The Experiment

The general plan of the experiment as well as the nature of the material used was suggested by Professor Woodworth. In general the procedure followed was the automatic presentation of a list of ten paired associates at two-second intervals, the associates consisting of a three letter word and a number of a single digit. After the first presentation of the series, a word was exposed alone to which the subject responded by pressing a key corresponding to the number he thought was associated with the word in the first presentation. (There were ten keys in all, numbered in order 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.) The pressure of the key caused the correct number to appear, to which the subject again reacted by pressing the corresponding number. This reaction caused the next word to appear, and the process was thus continued until he had responded three times to each word in the series. Four such lists were used with each subject, two in quiet and two in noisy conditions.

While the learning was in progress graphic records were taken of the time of each reaction, of the accuracy of the responses, of the subject's breathing, and of the amount of pressure he exerted upon the keys in reacting. Two days later the subjects were asked to recall as many of the words used in the experiment as possible; and after the recall test they were given the forty words that had been used, mixed with forty new words and they were asked to check those they recognized as having been used in the experiment. They were then given two chances to respond to each word with the number that had been associated with it in the presentation.

The apparatus was a modification of that used in our previous work on distraction.[3] The material to be presented was placed upon a disc which moved one sixteenth of a revolution every time the operating magnet received an electric current. Except for a small part the disc was hidden behind a movable screen. At each revolution of the disc a contact was made which caused (by means of an escapement movement[4]) the screen to move horizontally thus exposing a new part of the horizontal segment of the disc. As the disc moved a distance of 22.5 degrees at each reaction, there was a segment of 22.5 degrees which could be subdivided and used for varying exposures in the successive revolutions. In this case the segment was divided into nineteen parts thus enabling us to give a series of 304 exposures.

The first presentation of each list was controlled by a seconds pendulum which made contact every two seconds and operated by such contacts the exposure apparatus. This pendulum also made a connection every second and through this contact a time-line magnet was operated. Each key upon which the subject reacted was connected with a recording magnet. The keys as a whole were equipped with a pneumatic apparatus to record the pressure. All the recording material was in a separate room so that the subject was alone during the entire course of the work.

The distractions used were three in number. A graphaphone was played during each noisy period. At the same time a large fire gong and a buzzer placed behind the subject were kept sounding alternately at varying intervals of change.

The following lists present the associates that were used, the order representing that of the first presentation. In each

[3] *Ibid.*, 11-21.

[4] Three different adaptations of the escapement principle are now being used for exposing material in the Columbia Laboratory, and in every case with very satisfactory results.

succeeding presentation the order was changed so that serial associations could not factor.

ale - 9	oak - 9	gem - 7	arm - 5
bag - 6	pen - 8	roe - 1	bog - 1
ear - 7	son - 4	oil - 3	cat - 3
fir - 1	sty - 6	inn - 4	din - 8
hoe - 2	urn - 1	hay - 5	egg - 9
jew - 8	war - 3	law - 8	hat - 2
mud - 5	cog - 2	bee - 2	imp - 6
owl - 4	eye - 5	car - 0	joy - 7
pun - 3	fop - 7	fad - 6	lye - 0
sap - 0	jaw - 0	wit - 9	peg - 4

The directions given the subject will make clear the details of the presentation. They were given the directions to read before beginning the work, supplemented when they were not clearly understood by oral direction. The written directions were as follows: "Sometime after I leave the room the word 'ready' will appear at the exposure opening. Two seconds later and at two second intervals thereafter will appear a word and a number separated by a hyphen. Study these paired associates carefully and try to remember the number belonging to each word. After ten pairs have been exposed one of the words will appear alone. React to this word by pressing the key corresponding to the number that belongs to it. If you cannot think of the proper number, guess. The pressure of any key will expose the right number; to this you will react by pressing the corresponding key. For example, suppose in the first exposure you saw 'ice-2,' when ice appears alone you press the number you think you saw with it. If you press 3, it will cause the number 2 to appear, and you will then press 2. If you press 2 the first time, you will see by the appearance of the 2 at the opening that you were right and will press it a second time. A new word will appear only on the second reaction. Respond to each word in this manner until you see the word 'REST.' At the appearance of this word wait until another list of associates are exposed, beginning to react at the sight of the first word with no number attached. Always react with the index finger of the right hand."

The recall, recognition and retention tests were made as nearly as possible two days after the learning. For the sake of convenience a few of the subjects were permitted to do these outside the laboratory. In every case four envelopes were given numbered 1, 2, 3 and 4; together with four slips of paper on which were printed the following directions:

Directions for Envelope No. 1

In envelope number 1 you will find a sheet of blank paper. On it write all the words you can think of that were used in the experiment two days ago. (Not including Ready, Rest, etc.). Return the sheet to the envelope before reading directions for envelope number 2.

Directions for Envelope No. 2

In envelope 2 you will find a list of eighty words. Place a check mark after every word that you recognize as having been used in the test. Place a cross after every word that you recognize as not having been used. Place a ? after every word that you cannot place in either of the first two groups. Complete and return the paper to the envelope before reading directions for envelope number 3.

Directions for Envelope No. 3

In envelope 3 you will find a list of the words used in the experiment. Begin at the top and in order place after each word the number associated with it in the experiment. Place some number after each word. If you do not know, guess; but place a ? after each such number. Do not go back and correct any previous judgments. Record the time taken for this test. Return to the envelope before reading directions for test number 4.

Directions for Envelope No. 4

Proceed exactly as in the case of test number 3.

III. Results

Before presenting the results in detail it may be well to emphasize the fact that the material used was of such a nature that the forming of bonds was very difficult. In no case did the subjects report the use of any systematic scheme to aid in the learning. Incidental connections arose such as for one subject "car-0" suggested "Karo" Corn Syrup; "jew-8" was fixed easily by several subjects of jewish blood; "peg-4" by one subject was associated with a chair of four legs, etc.; but the majority of learning was purely rote. If this is borne in mind the significance of the results will be more apparent.

Twenty subjects, mostly psychology students, were used; eighteen were men and two women. For ten the first and third lists were given in quiet and the second and fourth in noise, while for the other ten the first and third lists were given in noise and the second and fourth in quiet. The order

in which the lists were presented was the same for all subjects. In computing the results (if we call one group of ten subjects A and the other group B) the first period of group A was averaged with the second of group B, the second of group A with the first of group B, the third of group A with the fourth of group B, and the fourth of group A with the third of group B. This method eliminates any chance factor that might have made one list more easily learned than the other and also takes account of practice effect. In viewing the results to ascertain the effects of the distraction only the periods should be compared which have been so combined, that is the first "quiet" column presented in the table may be compared with the first "noise" column and the second "quiet" column with the second "noise" column.

Table I gives the learning records of the twenty subjects in terms of the number of correct responses in a possible thirty, each series being given three repetitions besides the original presentation. If we compare the first noise period with the first quiet we find that two subjects had more correct responses

TABLE I

LEARNING RECORD. THE SCORES INDICATE THE NUMBER OF CORRECT RESPONSES IN A POSSIBLE THIRTY

Condition.....	Quiet	Noise	Quiet	Noise
Period.....	A	B	C	D
Subject *A*.....	9	6	9	11
B.....	6	13	6	9
C.....	17	7	6	8
D.....	25	22	23	21
E.....	10	9	17	13
F.....	12	12	8	11
G.....	22	22	24	17
H.....	22	6	20	22
I.....	5	3	10	7
J.....	15	9	14	11
Period.....	B	A	D	C
K.....	9	6	19	14
L.....	8	7	15	11
M.....	10	6	10	7
N.....	7	4	15	10
O.....	9	3	14	15
P.....	5	10	17	10
Q.....	11	5	11	8
R.....	17	12	17	10
S.....	15	3	10	20
T.....	30	28	27	28
Ave.....	13.2	9.6	14.6	13.15
P.E.m.....	1.1	0.96	0.91	0.85
	P.E.d 1.4		P.E.d 1.2	

in the noisy conditions, two the same number, and sixteen less. A comparison of the second two periods shows eight subjects having more correct and twelve less in the noisy than in the quiet. The difference between the averages of the first quiet and noisy periods is 3.6 with a probable error of the difference of 1.4, giving a difference 2.5 as great as the probable error. The difference between the averages of the second quiet and noisy periods is 1.5 with a probable error of the difference of 1.2. This shows that at first the noises were more of a hindrance than later, although the adaptation is not complete in the second period. That the second difference is so much less than the first would indicate that adaptation was setting in rapidly and that if the test were continued longer there would be no effect of the noises as far as the learning scores go. We have little doubt but that this would be the case since that is precisely what occurred in our former work, although there adaptation was very rapid. While on account of the adaptation that does show itself the learning scores do not indicate a permanent effect of the noises, we will later present evidence that it has a permanent effect in other respects.

TABLE II

TIME RECORD FOR FIRST RESPONSES. THE SCORES INDICATE THE AVERAGE TIME PER REACTION IN SECONDS

Condition.....	Quiet	Noise	Quiet	Noise
Period.....	A	B	C	D
Subject *A*.....	4.80	3.32	3.78	2.57
B.....	6.00	3.07	3.10	2.88
C.....	3.55	2.36	2.57	2.35
D.....	2.17	2.02	2.13	1.86
E.....	3.71	2.08	2.45	2.34
F.....	3.38	2.01	2.45	2.43
G.....	3.96	2.70	2.41	2.54
H.....	2.41	3.01	1.72	1.66
I.....	2.88	2.17	2.26	2.57
J.....	1.62	1.47	2.04	1.95
Period.....	B	A	D	C
K.....	2.19	2.90	2.07	1.91
L.....	3.17	4.13	3.09	3.43
M.....	5.00	7.42	5.18	5.38
N.....	3.12	4.22	2.75	3.11
O.....	3.17	3.54	2.27	2.10
P.....	3.15	3.10	2.37	2.90
Q.....	2.58	2.52	4.18	2.45
R.....	2.27	2.81	2.32	2.47
S.....	4.03	5.17	3.72	3.78
T.....	2.42	2.26	2.02	1.76
Ave.....	3.28	3.11	2.74	2.62
P.E.m.....	0.15	0.17	0.12	0.11
	P.E.d 0.23		P.E.d 0.16	

TABLE III

TIME RECORD FOR SECOND RESPONSES. THE SCORES INDICATE THE AVERAGE TIME PER REACTION IN SECONDS

Condition	Quiet	Noise	Quiet	Noise
Period	A	B	C	D
Subject *A*	1.72	1.77	1.35	1.35
B	1.66	1.47	1.67	1.37
C	1.30	1.35	1.28	1.21
D	1.17	1.03	1.02	.91
E	1.92	1.35	1.19	1.22
F	2.03	1.38	1.67	1.34
G	1.84	1.18	1.15	1.32
H	.96	1.14	.71	.70
I	1.45	1.28	1.19	1.27
J	1.25	1.19	1.06	1.03
Period	B	A	D	C
K	1.17	1.50	.97	1.05
L	1.57	2.42	1.37	1.41
M	2.33	3.82	2.03	2.80
N	1.92	3.32	1.73	2.08
O	1.54	2.07	1.02	1.15
P	1.82	1.72	1.32	1.54
Q	1.44	1.95	1.53	1.34
R	.92	1.41	.90	1.14
S	1.40	1.97	1.29	1.11
T	.86	.90	.63	.58
Ave	1.51	1.71	1.25	1.24
P.E.m	0.06	0.10	0.05	0.05
	P.E.d 0.12		P.E.d 0.07	

The time taken in reacting shows no significant change due to the noises. It will be remembered that there were two reactions to each word, the first was by pressing the number which the subject thought belonged with the word exposed, the second was to react to the correct number which the first reaction caused to appear. We shall designate the first pressure as the first response and the reaction to the correct number as the second response. The two were computed separately; those for the first responses appear in Table II, while those for the second responses are given in Table III. It is evident that in the case of the first responses there is no loss in speed as a result of the distractions, what little difference there is lies in the direction of greater speed during the noise periods. In each comparison twelve subjects show faster time and eight slower in the noise periods. The difference between the averages of the noise and quiet periods falls within the range of pure chance.

The explanation of the lengthening of the time of the second

responses in the first noise period is not apparent, but as the difference between the average of this period and the first quiet period is only slightly greater than the probable error of the difference it is likely a chance difference. A comparison of the times of the second quiet and noisy periods certainly indicates no effect of changed conditions; ten subjects made slower time, one the same and nine less, while the averages are almost identical.

TABLE IV

BREATHING RATIOS. THE SCORES INDICATE THE AVERAGE RATIO FOUND BY DIVIDING THE EXPIRATION TIME BY THE INSPIRATION TIME

Condition	Quiet	Noise	Quiet	Noise
Period	A	B	C	D
Subject *A*	2.28	2.62	1.97	2.50
B	2.19	2.69	2.73	2.42
C	1.41	1.28	1.41	1.38
D	1.27	2.51	1.44	2.49
E	1.94	1.87	2.85	2.22
F	2.03	1.61	2.01	1.73
G	1.53	1.30	1.32	1.59
H	2.32	2.67	2.07	2.04
I	1.78	1.96	2.19	2.39
J	1.56	1.67	1.52	1.65
Period	B	A	D	C
K	2.16	2.34	3.10	2.15
L	2.86	2.28	2.54	3.80
M	3.70	2.34	2.91	6.24
N	1.68	2.04	2.00	2.04
O	1.97	1.87	1.75	1.82
P	3.10	2.56	2.37	2.73
Q	1.47	1.84	1.75	2.42
R	1.62	2.41	1.53	1.64
S	2.62	3.97	2.24	2.83
T	2.69	2.25	2.05	2.52
Ave	2.11	2.20	2.09	2.43
P.E.$_m$	0.09	0.08	0.09	0.11
	P.E.$_d$ 0.12		P.E.$_d$ 0.15	

In our previous work on distraction it was found that with the task we used articulating served as a great aid in the accomplishment of the work; consequently the subjects showed a strong tendency to use this means to help overcome the disturbing effect of the noise. We recorded this tendency through the comparison of the expiration and inspiration times. When one speaks, or moves even slightly the organs of articulation, the inspiration time is shortened and the expiration time lengthened. The ratio of the expiration to the inspiration is there-

fore changed and may be used as a scale of the extent of such articulatory movements.

Table IV presents the ratios for our twenty subjects in the two periods with each condition. The first noise period causes no marked difference in the ratio while the second one shows a slight tendency toward an increase in ratio for the noisy period. Fourteen subjects have a larger ratio and six a smaller. It will be seen however that in only a few cases is the increase very marked, and we must conclude that the tendency to articulate in the work of memorizing the material we used is slight. This is not surprising, for an analysis of the process involved shows little help could be gained by speaking the words and numbers in comparison with the help that could be gained in the task used in our previous work. There the subject had to look at the exposure opening where he perceived a letter from the latter end of the alphabet on a background of one of three colors. He then looked below the opening to a code by means of which he translated the exposed letter to one from the beginning of the alphabet. This letter he translated to a number by selecting from three codes one colored similarly to the background of the exposure, and having obtained the number from this code pressed the key; whereupon the exposure was changed and the process repeated. In this complex procedure lip movements, whispering, or speaking aloud aided materially and these helps were used by a large number of subjects. Very slight movements would serve to repeat the word and number of a paired associate and hence we believe the difference in the tasks in the two experiments explains the difference in the results obtained. However even in this test such aids were used to some extent for the difference in the ratios of the last quiet and noise periods is 2.3 times the probable error of the difference.

Another and by no means the least important record taken during the learning period was that of the pressure used by the subjects in reacting upon the keys. The keys were accurately and delicately adjusted and the least pressure upon them was, by a pneumatic connection, recorded upon a smoked drum. As the contacts were of mercury a very light pressure served to make contact.

In Table V are given the average pressures in grams for each of the lists learned, two in each condition for each subject. There is a marked tendency to press the keys harder when noise disturbance is in progress than when surroundings are quiet. Fourteen subjects react with greater pressure in the first noise period than in the first quiet while sixteen

TABLE V

KEY PRESSURES. THE SCORES INDICATE THE AVERAGE PRESSURE IN GRAMS

	Condition.....	Quiet	Noise	Quiet	Noise
	Period.....	A	B	C	D
Subject	*A*.....	395	257	260	188
	B.....	225	325	145	218
	C.....	390	337	235	175
	D.....	460	550	352	593
	E.....	1038	922	825	655
	F.....	362	1135	440	710
	G.....	130	118	140	185
	H.....	572	708	582	630
	I.....	358	325	212	313
	J.....	1165	900	745	625
	Period.....	B	A	D	C
	K.....	522	1000	595	815
	L.....	220	565	187	208
	M.....	475	1425	155	435
	N.....	242	762	180	235
	O.....	115	175	165	168
	P.....	112	168	77	112
	Q.....	147	448	75	197
	R.....	1422	1718	905	1475
	S.....	88	260	43	68
	T.....	207	420	90	100
	Ave.....	432	625	320	405
	P.E.$_m$.....	50	67	42	51
			P.E.$_d$ 83		P.E.$_d$ 66

react with greater pressure in the second noise period as compared with the second quiet. In each case a comparison of the averages shows a reliable difference, the difference being more reliable in the first than in the second comparison. This is the opposite of the results of the breathing ratios, where the second comparison showed a more reliable difference. These two sets of facts point to the conclusion that the introduction of noise causes the subjects to strain to overcome them, the strain being most marked at the beginning and lasting, although not to such a marked degree, throughout the noisy conditions, giving place to relaxation when they cease. The fact that the breathing changes most in the latter period indicates that it takes some time to adopt articulation as an aid.

In these records of articulation and key pressure we by no means have an adequate check on all the ways in which the subjects oppose the effects of the noises. They do however throw valuable light upon the subject's behavior, light

that could never be obtained from the usual methods of merely recording speed and accuracy. No two subjects were affected alike, as a close study of all the tables will show, and some undoubtedly opposed the noises by reactions upon which we had no check; nevertheless the measures we did get connect with the speed and accuracy scores fairly well. If we take the second periods of quiet and noise, when the subjects had become somewhat adapted to the situation, and compare the different individuals we will see that;—of the eight individuals who made a better learning score in the noisy period only one had neither a higher breathing ratio record nor a higher key pressure record in that period, one had a higher breathing ratio record and a lower key pressure record, three had a higher key pressure record and a lower breathing ratio, while three had both a higher breathing ratio and key pressure score; of the twelve who made a lower learning score in the noisy period nine had both a higher breathing ratio and key pressure score, one had neither and the other two had one score higher and the other lower. This is certainly evidence of wide individual variation. Some in spite of effort and articulation were still unable to make as good a score in the noisy condition as in the quiet, others were able to make as good a score with these aids, while one did so without giving us any evidence as to the means of his so doing.

Now if by any possible means we could get enough simultaneous measures of an individual during an experiment so that every possible reaction in any direction whatsoever could be measured, a composite expression of all these measures would correlate perfectly with the measures of efficiency provided we had a perfect measure of work done per unit of time along with a perfect measure of quality. If then any disturbing factor should be introduced it would either affect the efficiency score; or, if the subject overcame it by some adaptive reaction, the composite figure expressing his reactions *in toto* would be changed. Those individuals who stood highest in the efficiency score under such conditions would show the greatest amount of change in the composite measure of adaptive reactions, those lowest in the efficiency scale would show the least change in the reaction measure. If some outside factor were introduced in an endeavor to ascertain what influence it had and neither score was changed it could be safely inferred that it had no bearing on the task in hand. If this is so, and if in our experiment the noises had any effect, and if the tests we used were at all adequate we should get some sort of correlation between the efficiency

score and the measures of the individual's changes in reactions of an adaptive sort. Since our tests make no boast of being comprehensive we could not expect a perfect correlation.

To get such a correlation we found the amount of each individual's superiority in the noisy period over the quiet; that is, if a score of 5 were made in quiet and 4 in noise the superiority was —1, if the time in quiet was 2.2 seconds and in the noise 2 seconds the superiority was .2 of a second. We proceeded in like manner with the breathing ratio and key pressure scores counting a higher score in the noise period as a plus difference. Having found these differences we arranged the subjects according to their relative ranks as to these differences in each test, the greatest plus difference being one and the greatest minus difference being twenty. The average rankings for each subject were then found for the learning and time, and for ratio and key pressure. In the case of the comparison of the first quiet and noisy periods the correlation between these two average rankings was .35 (P.E. .138), and in the case of the second quiet and noisy periods .57 (P.E. .11). That the correlation is higher in the second comparison is significant. In the first change in situation the adaptive reactions did not factor nearly as much as in the second change, the subjects were more or less bewildered while in the second they settled down to overcome the disturbing effect; hence it would be expected that the correlation would be higher in the second comparison.

That a single measure would not have been nearly so adequate is shown by the fact that, if from the same relative rankings of the differences, taking the comparison of the second periods, we compute the correlation betwen time and key pressure, we find it to be —.05, and that between breathing ratio and amount learned is only —.04, that between key pressure and the average of the learning and time .14 (P.E. .15), and that between the breathing ratio and the average of time and learning in .28 (P.E. .145).

We likewise have evidence that the associative bonds that were formed during the noisy conditions were more superficial than those formed in the quiet periods. In Table VI may be seen the results of the retention test taken after a two day interval. The scores represent the number of correct associations given in two trials, that is, the correct responses in a possible 20. Here in each case we have a lower score for the noisy than for the quiet periods. If we find what per cent the retention scores are of the learning scores in each of the four lists we find for the first list the

TABLE VI

RETENTION OF ASSOCIATIONS. THE SCORES INDICATE THE NUMBER OF CORRECT RESPONSES IN A POSSIBLE TWENTY. SUBJECT M. FAILED TO COMPLETE THIS PART OF THE EXPERIMENT

Condition	Quiet	Noise	Quiet	Noise
Period	A	B	C	D
Subject *A*	3	1	7	7
B	4	4	2	3
C	1	5	7	1
D	7	3	8	4
E	5	5	4	4
F	5	4	3	12
G	9	4	6	1
H	3	1	3	4
I	3	2	4	2
J	3	2	6	3
Period	B	A	D	C
K	3	3	4	3
L	4	4	4	5
M	..	..	..	..
N	3	1	6	5
O	6	0	6	6
P	1	3	3	3
Q	2	2	0	0
R	1	1	4	2
S	5	2	2	7
T	9	2	7	0
Ave	4.05	2.58	4.52	3.78
P.E.m	0.34	0.23	0.34	0.40
	P.E.d 0.41		P.E.d 0.52	

per cent of retention was 30.7, for the second 26.8, for the third 30.9, and for the fourth 27.6. In each case there is a lower percentage retained of the list learned in noise than of the list learned in quiet. Moreover adaptation does not seem to have helped as far as retention goes for the difference in percentage is about as great between lists three and four as between one and two.

We have so far seen that in spite of extra expenditure of effort and to some extent the aid of articulation to overcome the effect of the noise the amount of material learned and the amount retained after two days was less in the noisy conditions than in the quiet. Here we have a task that suffers when attention is divided in spite of the efforts of the subjects to overcome the disturbance. The increased effort likely helped them somewhat in the learning by increasing their immediate memory as is shown by the learning scores, but the retention scores show that it did not aid them to form any

permanent associative bonds, which is the essential thing in memorizing. This may not have been so had we used sense material, as increased activity and effort would in this case probably aid the subjects in getting additional bonds; but when the process is that of rote memory concentrated attention is more essential than increased effort.

Besides the effects already noted we have evidence that the range of attention was diminished during the noisy periods. The subjects were not asked to memorize the words used and the constant change of arrangement with each presentation discouraged any attempt at forming successive associations. To test memory for the words used would, under these conditions, be a test of memory for incidental factors in the experiment. To get a measure of the effect of the noises on these incidental associations both a recall and a recognition test were used. Two days after the experiment each subject was asked to write all the words he could recall that were used in the experiment, and after he had done this he was

TABLE VII

WORD RECALL. THE SCORES INDICATE THE NUMBER OF WORDS RECALLED IN A POSSIBLE TEN

Condition.....	Quiet	Noise	Quiet	Noise
Period.....	A	B	C	D
Subject *A*.....	0	0	1	1
B.....	2	0	1	1
C.....	2	2	1	1
D.....	3	2	1	3
E.....	3	1	1	4
F.....	4	6	2	5
G.....	1	1	1	1
H.....	1	0	1	1
I.....	2	2	4	4
J.....	1	1	0	0
Period.....	B	A	D	C
K.....	1	2	2	0
L.....	2	2	3	2
M.....	1	2	1	0
N.....	3	1	0	0
O.....	3	1	4	2
P.....	1	2	3	0
Q.....	0	1	0	0
R.....	2	2	4	1
S.....	3	2	2	2
T.....	1	1	1	0
Ave.....	1.8	1.55	1.65	1.4
P.E.m.....	0.17	0.16	0.20	0.22
	P.E.d 0.23		P.E.d 0.30	

TABLE VIII

WORD RECOGNITION. THE SCORES INDICATE THE NUMBER OF WORDS CORRECTLY RECOGNIZED WHEN MIXED WITH AN EQUAL NUMBER OF WORDS THAT HAD NOT BEEN USED IN THE EXPERIMENT. THE HIGHEST POSSIBLE SCORE IS TEN

Condition	Quiet	Noise	Quiet	Noise
Period	A	B	C	D
Subject *A*	5	2	4	4
B	7	7	9	3
C	7	7	7	9
D	6	6	6	9
E	7	3	5	7
F	7	9	6	8
G	6	7	9	8
H	7	3	6	5
I	10	9	10	5
J	5	9	7	3
Period	B	A	D	C
K	8	8	10	9
L	4	5	6	7
M	7	8	9	9
N	4	3	7	3
O	5	2	7	4
P	5	4	4	5
Q	6	5	6	2
R	5	6	5	7
S	9	8	7	8
T	7	6	8	6
Ave	6.35	5.85	6.90	6.05
P.E.m	0.24	0.37	0.27	0.39
	P.E.d 0.44		P.E.d 0.47	

presented with a sheet containing all the words used mixed with forty new words and asked to check all those he recognized, in accordance with the directions given above. The scores for these two tests are given in Tables VII and VIII respectively.

In the recall test the average number of recalls is less for the noisy periods in each case than for the quiet, though owing to the limited number of recalls the difference is not very significant. In the comparison of the first two periods five subjects recalled a greater number and seven less, while for eight the scores in each condition were equal. A comparison of the second periods shows that three recall a greater number for the noisy period, seven a less number and ten the same.

In the recognition test the differences are a little more significant, the second comparison showing a difference 1.9

times the probable error of the difference. The differences in both these tests are not positive evidence of a very strong influence of the distractions on incidental memory, but that in each case the difference is in the direction of inferiority for the noisy period together with the fact that in every case but one the difference is greater than the probable error of the difference gives the evidence cumulative force.

IV. Conclusions

1. The learning of paired associates consisting of a three letter word and a digit is interfered with by noise, the interference being greater at first than later in the working period.

2. The time which the subjects take to respond in learning when they are given the privilege of setting their own pace is not changed to any reliable degree by noise. What little difference in time is apparent is in the direction of quicker reactions in the noisy conditions.

3. Articulation as indicated by the breathing ratio is used to overcome the effect of the noises more in the latter part of the working period than in the earlier part.

4. It is evident from the severity of the blows given in reacting that the subjects were in a state of greater tension in the noisy conditions than in the quiet. This tension was greater in the first noise period than in the second.

5. The amount of material retained after two days is less for material learned in noisy conditions than for that learned in quiet. The difference is as great for the second period of noise as for the first.

6. That the range of attention for incidental factors of the work in hand is decreased by noise is shown by the lower recall and recognition scores for the words of the lists used in the noisy periods.

7. The results obtained in this experiment show that the task of memorizing material which is from its nature rather bare of associative bonds is a good one to test the effect of distraction. While adaptation is apparent in the learning it does not counterbalance entirely the distraction effect, and the additional tests of retention and incidental associations give further data for interpretation. Material like word paired-associates might however show the reverse effect as the additional effort called forth by the more difficult situation might lead to the forming of more permanent associations.

8. Our results taken together indicate that irrelevant noises have a permanent effect upon an individual. One may adapt

himself insofar as the assigned task is concerned but if tests are taken for which he is not prepared it will appear that the adaptation is through loss in some other direction. He may show less permanency of associative bonds, he may have done the work at a greater strain, he may have used some trick to overcome the effect, or he may have grasped fewer of the incidental features of the work; he may show any or all of these effects and others also might be found had we adequate measures, but in some way he pays in order to keep his speed and accuracy up to par.

9. Finally, the value of a group of measurements simultaneously taken cannot we believe, be overestimated. If a dozen tests are given to the same individual at different times he will be able to adapt himself to each test in spite of unfavorable conditions and the pooled results of such a group of measures will show nothing. If however he is given one test and a dozen other measures are taken while he is working, if there is any effect of the conditions it will show itself in some way or other. Any one can adapt himself to conditions so that the work in hand will show little or no effect of any ordinary disturbance or even of an extraordinary one (it is the habit of the human organism to so adapt itself) but the object of studying the effects of environmental conditions is not to find whether one can so adapt himself, it is to see by what means he does so. Regardless of the difficulties involved in the way of technique the method of simultaneous measures must take precedence over the one-test-at-a-time method, the futility of which as a test of conditions has been fully demonstrated in recent years.